WHAT IS CLAIMED IS:

1. A distributed control system for a material transport system, comprising:

a high-level controller;

at least one mid-level controller coupled to the high level controller; and

a plurality of low-level controllers coupled to the at least one mid-level controller;

in response to commands from a respective mid-level controller, each of the low-level controllers being configured to control directly a respective group of one or more electromechanical devices, the group being selected from a plurality of electromechanical devices composing the material transport system;

the respective mid-level controller being configured to formulate the commands in accordance with local goals formulated for the respective mid-level controller by the top-level controller;

the top-level controller being configured to formulate the local goals in accordance with a global goal for a transfer operation pending in the material transport system.

2. The distributed control system of claim 1, wherein, when the global goal comprises a transfer command requesting movement of a particular package from one station of the material transport system to another station, the high-level controller determines a sequence of the local goals necessary to implement the transfer command and issues the local goals to the mid-level controller.

3. The distributed control system of claim 2, wherein the local goals comprise a series of acquire, move and deposit commands that are executed by at least one of the mid-level controllers.

4. The distributed control system of claim 1, wherein the material transport system comprises a transport system employed in a semiconductor fabrication facility to move at least one of:

one or more semiconductor wafers between processing stations;

one or more semiconductor wafers between the processing and metrology stations;

one or more semiconductor wafers between the metrology stations;

one or more reticles to respective ones of the processing stations.

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5. The distributed control system of claim 4, wherein the electromechanical devices comprise at least one of:

a zone including a length of track, at least one drive motor for driving the pod along the track, and at least one sensor for sensing presence of the pod within the zone;

a director for providing rotational movement between at least two zones whose track portions meet at other than a 180 degree angle; and

a Load Port Transfer Device (LPTD) for coordinating the pod into and out of the load zone.

6. The distributed control system of claim 1, wherein the material transport system comprises a transport system employed in a manufacturing facility selected from a flat panel display manufacturing facility, a magnetic storage disk drive manufacturing facility or a pharmaceutical manufacturing facility, such that:

when used in the flat panel display manufacturing facility, the material transport system is used to move flat panels or flat panel components between flat panel manufacturing stations;

when used in the magnetic storage disk drive manufacturing facility, the material transport system is used to move magnetic storage disks or disk assemblies between disk drive manufacturing stations; and

when used in the pharmaceutical manufacturing facility, the material transport system is used to move pharmaceutical components between pharmaceutical manufacturing stations.

7. A method of configuring a distributed control system for a material transport system, comprising:

defining a set of neighborhoods including electromechanical devices composing the material transport system, wherein each of the neighborhoods includes the electromechanical devices that are likely to interact based on topology of the material transport system;

providing a low-level controller for the electromechanical devices, the low-level controllers being configured to translate generalized control commands to low-level control commands for the respective electromechanical device and to report status of the respective electromechanical device;

providing a higher-level controller that controls all low-level controllers associated with at least one of the neighborhoods via the generalized control commands;

compartmentalizing processing within the higher-level controller so that information regarding no more than the electromechanical devices composing the associated neighborhood is used to formulate the generalized control commands for low-level controllers associated with that one neighborhood.

8. A computer program product for use in a material transport system including a plurality of electromechanical devices and a control computer, wherein the computer program product includes a computer memory coupled to the control computer and a computer mechanism defined therein, the computer mechanism comprising:

control threads that configure the control computer to control and monitor operations of the electromechanical devices;

one of the control threads associated with a particular electromechanical device communicating with others of the control threads associated with a group of electromechanical devices that interact with the particular electromechanical device so that the one control thread and the others cooperatively accomplish a goal involving movement of material using the particular electromechanical device and the group of electromechanical devices.

9. The computer program product of claim 8, wherein:

the particular electromechanical device is a particular track zone and the group of electromechanical devices are other track zones neighboring the particular track zone, each of the track zones being configured to accelerate the material;

such that the one thread causes the particular track zone to accelerate the material to a target value, determines a set of future target values to which the material should be accelerated by the other track zones, and issues commands to the others of the control threads indicating respective ones of the set of future target values.

10. The computer program product of claim 8, wherein the particular electromechanical device and the group of electromechanical devices form a neighborhood of the electromechanical devices likely to interact during operations of the material transport system.

11. The computer program product of claim 8, wherein:

the material comprises a plurality of material units;

movement of each of the material units is independently controlled by the control threads; and

the control threads are configured so that the control threads that control the electromechanical devices composing a particular neighborhood in which a plurality of the material units are simultaneously moving can cooperatively accomplish a goal involving movement of the multiple material units towards respective destinations without collisions occurring.

12. A distributed method for controlling movement of material to be transported in a material transport system, comprising:

defining a neighborhood including a contiguous subset of electromechanical devices composing the material transport system, the electromechanical devices including track zones configured to control the movement of the material and to report zone status information;

providing low-level controllers to control the subset of electromechanical devices and to receive status information from the electromechanical devices, the low-level controllers including zone controllers, each of which is configured to control and receive zone status information from a respective track zone and to receive messages from zone threads in the neighborhood; and

configuring each of the zone threads to:

determine using the zone status information when the material is entering a respective track zone;

determine from stored information updated by a neighboring, upstream zone thread an entry speed at which the material is entering the respective track zone;

issue a motor control command to the respective track zone to establish the speed of the material in accordance with a speed profile message forwarded by the upstream zone thread and the entry speed;

determine from the stored information updated by neighboring, downstream zones the speed at which the material should enter a neighboring downstream zone;

determine from a potential entry speed and location of a destination of the material a speed profile of the material in one or more neighboring, downstream zones,

send the speed profile message to the one or more neighboring, downstream zones causing the speed profile to be executed.

13. The distributed method of claim 12, further comprising:

configuring each of the zone threads to issue an exiting message to neighboring zones when the material begins exiting the respective zone.

14. The distributed method of claim 13, wherein the neighboring zones to which the exiting message is issued comprise those neighboring zones whose execution of a speed profile would be affected by the location of the material within the neighborhood.

15. The distributed method of claim 12, wherein the speed profile message comprises:

a begin speed index indicting speed of the material at initialization of execution of the speed profile; and

an end speed index speed of the material at completion of execution of the speed profile;

the speed indices being associated with actual motor speeds to which the track zone accelerates the material to accomplish the desired speed profile.

16. The distributed method of claim 12, wherein the speed profile is selected from an acceleration, deceleration , constant velocity or triangular speed profile.

17. The distributed method of claim 12, wherein the stored information comprises a speed table listing for each of the neighboring downstream zones a maximum speed at which a particular unit of material can exit that neighboring downstream zone.

18. The distributed method of claim 12, wherein the maximum speed can be set to a first value indicating that the zone is unavailable for material movement, a second value indicating that the zone is reserved for material movement or a third value representing an actual material ~~speed.~~

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~~19.~~ A distributed method for routing material from a source to a destination in a material transport system ~~including~~ track zones and directors connecting the track zones, comprising:

launching the material from ~~the source~~;

when the material enters a track neighborhood that includes a director through which the material must pass to proceed to the destination, notifying the director of the approach of the material;

the director, in response to the notifying, selecting an optimal route for the material based on the destination and stored routing information indicating for each material transport system destination a director exit angle and a metric characterizing quality of a path to the destination originating from the director exit angle; and

the director subsequently decelerating the material, rotating to the director exit angle associated with the optimal route and relaunching the material along the optimal route.

20. The distributed method of claim 19, further comprising:

modifying the stored routing information to account for routes that become unavailable during operation of the material transport system.

21. The distributed method of claim 20, wherein a route becomes unavailable due to:

failure of the route's destination;

failure of a track zone between the director and the route's destination;

failure of one or more intervening directors between the director and the route's destination; and

disablement of the route by a material transport system operator.

22. The distributed method of claim 19, wherein the metric associated with a particular exit angle and destination is determined for a new director as follows:

(1) the new director sends a path query to an immediate downstream neighbor at the particular exit angle;

(2) in response to the path query:

(2a) when the immediate downstream neighbor is the destination: the destination increments the metric to indicate the quality of the route to the destination and returns the incremented metric to the new director;

(2b) when the immediate downstream neighbor is a track zone: the track zone increments the metric to indicate the quality of the route through the track zone to the destination, resends the path query with the incremented metric to an immediate downstream neighbor of the track zone, which repeats operation (2); and

(2c) when the immediate downstream neighbor is another director: the other director increments the metric to indicate quality of the route from the other director to the destination and returns the incremented metric to the new director.

23. The distributed method of claim 19, wherein the metric is a function of at least one of:
route length;
route transit time; and
route congestion.

24. The distributed method of claim 19, further comprising:

(1) when a new destination is added to the material transfer system, the new destination announces its presence to its immediate upstream neighbor using a dest_announce message;

(2) in response to the dest_announce message:

(2a) when the immediate upstream neighbor is a track zone, the track zone increments a metric associated with the announce message that characterizes quality of a path from the new destination to the immediate upstream neighbor, resends the announce message with the updated metric to an immediate upstream neighbor of the track zone, which repeats operation (2);

(2b) when the immediate upstream neighbor is a first director: the first director increments the metric to indicate quality of the route from the first director to the new destination, stores the metric along with the exit angle and identify of the new destination and returns a registered message informing the new destination that it has been registered.

25. The distributed method of claim 24, further comprising,
when the immediate upstream neighbor is the first director:

the first director announces the new destination to adjacent directors with route_announce messages indicating a cumulative metric representing the metric from the first director to the new destination and the metric between the first director and respective ones of the adjacent directors;

repeating an operation wherein each of the adjacent directors updates their stored information for an appropriate exit angle with the cumulative metric and resends the

route_announce message to their adjacent directors until the route_announce message arrives back at the first director.

26. The distributed method of claim 19, wherein the stored information for each of the routes comprises:

the destination

the exit direction;

whether the route is direct, meaning there are no intervening directors, or via, meaning there is at least one intervening director;

the metric characterizing goodness of the route; and

the route status.

27. The distributed method of claim 19, further comprising:

when the material comprises two or more material units moving in one neighborhood in need of routing through the director, the track zones cooperatively route the material units to the director so there is no possibility of a collision between the material units and the material units continue to move forward at optimal speeds.

28. The distributed method of claim 19, wherein the track zones are unidirectional, further comprising:

configuring the transport system for bidirectional movement within one neighborhood by:

arranging a subset of the directors in a director cluster of two or more directors;

enabling exit angles for each of the directors in the director cluster to permit the material moving in one direction on a first unidirectional track zone segment in the neighborhood to be turned using two or more of the directors in the director cluster onto a second unidirectional track zone segment for movement in another direction in the neighborhood.

29. The distributed method of claim 28, wherein the director cluster comprises a number of directors selected to prevent deadlock conditions where one or more material units needing

to move through the director cluster are prevented from moving due to each others presence in vicinity of the director cluster.